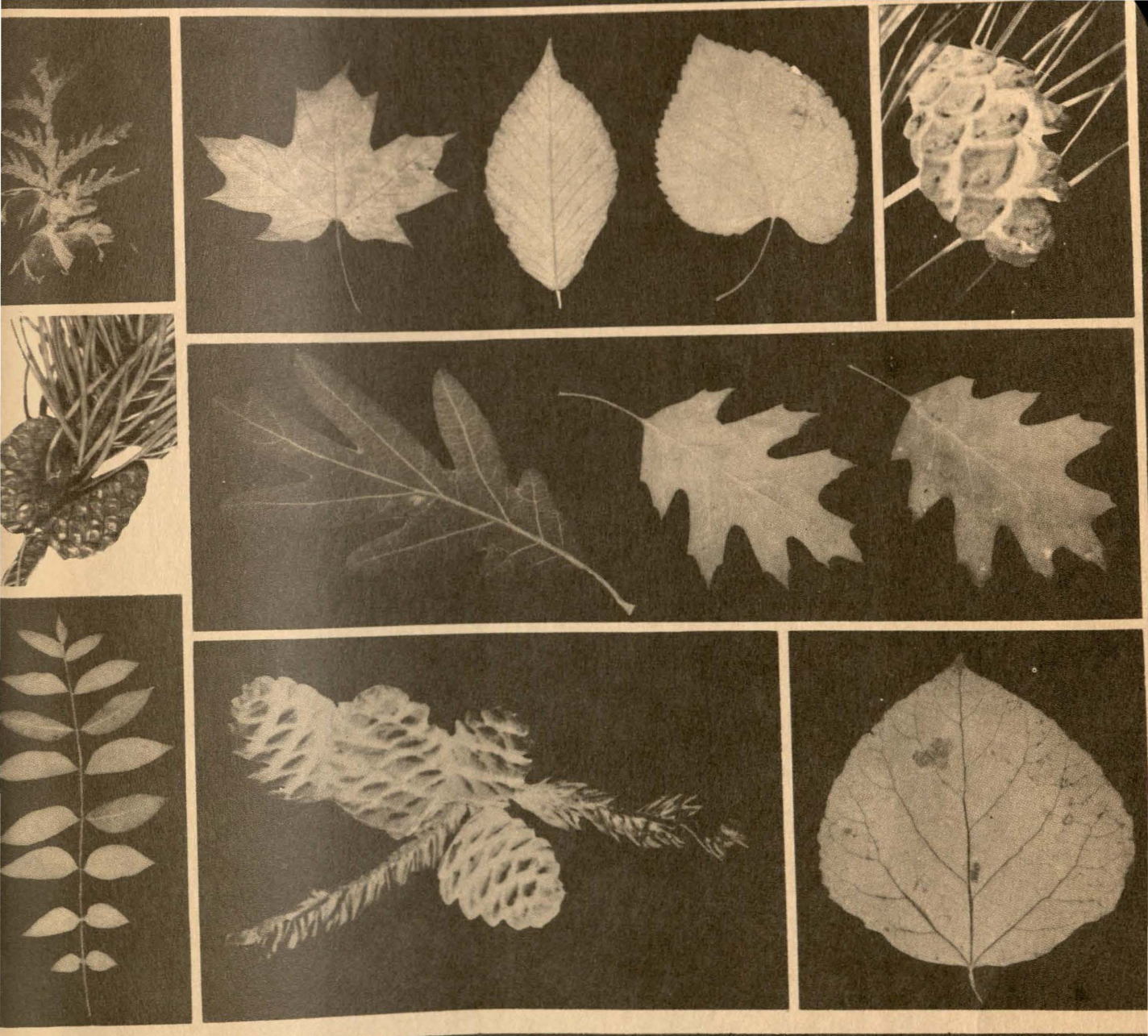

manager's handbook for

JACK PINE IN THE NORTH CENTRAL STATES

GENERAL TECHNICAL REPORT NC-32

NORTH CENTRAL FOREST EXPERIMENT STATION FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Other Manager's Handbooks are:

Red pine – GTR-NC-33
Black spruce – GTR-NC-34
Northern white-cedar – GTR-NC-35
Aspen – GTR-NC-36
Oaks – GTR-NC-37
Black walnut – GTR-NC-38
Northern hardwoods – GTR-NC-39

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FOREWORD

This is one of a series of manager's handbooks for important forest types in the north central States. The purpose of this series is to present the resource manager with the latest and best information available in handling these types. Timber production is dealt with more than other forest values because it is usually a major management objective and more is generally known about it. However, ways to modify management practices to maintain or enhance other values are included where sound information is available.

The author has, in certain instances, drawn freely on unpublished information provided by scientists and managers outside his specialty. He is also grateful to the several technical reviewers in the region who made many helpful comments.

The handbooks have a similar format, highlighted by a "Key to Recommendations". Here the manager can find in logical sequence the management practices recommended for various stand conditions. These practices are based on research, experience, and a general silvical knowledge of the predominant tree species.

All stand conditions, of course, cannot be included in the handbook. Therefore, the manager must use technical skill and sound judgment in selecting the appropriate practice to achieve the desired objective. The manager should also apply new research findings as they become available so that the culture of these important forest types can be continually improved.

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JACK PINE
IN THE NORTH CENTRAL STATES

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SILVICAL HIGHLIGHTS

Wildfires following early pine logging, and extensive planting programs in the 1930's, increased the extent of jack pine[1] in Minnesota, Wisconsin, and Michigan. However, its present area of 2.5 million acres[2] is decreasing as jack pine stands are converted to other species.

Jack pine grows in extensive pure stands but is also frequently mixed with red and white pine, aspens, paper birch, and scrub oaks; less often it is mixed with black spruce, white spruce, and balsam fir. Jack pine is intolerant of shade. It is often a pioneer species on burns or bare sandy soil and is usually succeeded by more tolerant species on all but the dry sandy sites where it may form an edaphic climax.

Although jack pine is a short-lived tree, a few individuals may live for more than 200 years, and stands sometimes survive up to 100 years. Commercial rotation ages are generally between 40 and 70 years when mature trees are usually 8 to 12 inches d.b.h. and 50 to 80 feet tall.

Jack pine is susceptible to severe losses from several diseases and insects, as well as from browsing or girdling by animals, and from breakage by wind, ice, hail, and snow storms. Fires also easily kill jack pine but they play an important role in establishing many seedling stands by killing the shrub and tree competition, preparing seedbeds, and melting the resin on the scales of the serotinous cones to release seeds.

Cones are generally serotinous over much of the jack pine range; many of these closed cones persist on the tree for years resulting in large accumulations of seed in unopened cones. Some trees, however, particularly in the southern part of the jack pine range, bear non-serotinous cones which open as soon as they mature and disperse their seeds promptly. Good seed crops are produced at 3- to 4-year intervals from about age 20, but best seed production is on trees 40 to 50 years old.

Considerable variations in vigor, wood characteristics, stem and crown form, cone characteristics, and resistance to insects and disease provide opportunities for genetic improvement.

MANAGEMENT OBJECTIVES

Jack pine is a short-lived, intolerant, pioneer species that occurs primarily as a temporary type on the better sites, but on the deep, dry outwash sands, where other commercial tree species do poorly, it is a more permanent type. Management objectives considered in this handbook are (1) to maintain the jack pine type where it is the best suited species and (2) to replace it with a more suitable species on other sites at the end of the jack pine rotation. Intermediate thinnings are recommended for jack pine stands on the better sites (site index 60 or more) managed for the production of poles and small saw logs. Most jack pine stands, however, will be managed for pulpwood without intermediate thinnings except for densely overstocked seedling stands that need to be weeded to reduce the risk of stagnation, shorten the rotation, and increase the pulpwood yield.

[1] *For scientific names of plants and animals, see Appendix, p. 15.*

[2] *For metric equivalents, see Appendix, p. 15.*

Jack pine seedlings require full sunlight to become established. The recommended silvicultural system may be clearcutting, seed tree, or shelterwood, depending on various conditions such as seed tree quality, cone habit, slash disposal methods, and seedbeds. Planting may be needed to establish jack pine on some sites but on many areas scattering branches with serotinous cones or sowing repellent-treated seed on mineral soil seedbeds will be successful. Natural regeneration by the seed tree or shelterwood system depends on the availability of good quality seed trees. The seed tree system is recommended only for stands with serotinous cones where prescribed burning can be used for site preparation and the heat of the fire will open the cones on the seed trees. If the trees have nonserotinous cones, the shelterwood system may be used.

Major problems in managing jack pine stands involve stand establishment and protection. Weather conditions are often more critical on dry sandy soils where droughts and high temperatures can severely hinder stand establishment. Protection problems are also influenced by weather factors that increase environmental stresses on the trees. Wind, snow, ice, and hail storms can be especially damaging to jack pine stands. Other problems include insects, diseases, and fire.

The acreage of jack pine increased after the original pine logging because wildfires encouraged natural seeding and there were extensive planting programs in the 1930's. These jack pine stands show large differences in growth rates and pest resistance. Many areas could be more productive if improved jack pine seeds or trees were used for establishing new stands on these sites or if the jack pine stands were replaced with a more productive forest type at the end of the rotation. Better guidelines are needed to select improved jack pine for establishing stands on the dry, sandy sites where jack pine has an advantage over other species and to compare jack pine productivity with other suitable species on all sandy sites.

Jack pine forests can be managed for timber and still provide wildlife habitat for several species of mammals and birds including deer, hare, and Kirtland's Warbler. Practices to ensure and protect other resources such as recreation and water along with timber are also discussed in the handbook.

KEY TO RECOMMENDATIONS

The following key is based primarily on the technical aspects of forest management – silviculture, protection, and regulation. The administrative aspects – economic, legal, and social – have only limited indirect influence in the key so the user is cautioned to evaluate these aspects carefully when applying the technical recommendations.

The key recommends management practices for some of the common site and stand conditions encountered in the jack pine type or on potential jack pine sites. Use of the key in conjunction with a stand examination will lead to one or more general recommendations. Each recommendation refers to the appropriate section under "Management Considerations" where optional silvicultural tools and methods are discussed.

To use the key, start with the first pair of numbered statements. Choose the statement that best describes the situation and find a number only, a recommendation and a number, or a recommendation only. If a number is given, find the pair of statements with that number and continue the process until a recommendation only is reached. All recommendations encountered in going through the key should be considered in your prescription.

1. Jack pine stand with minimum or higher stocking 2
See "Type" and "Stand Density", p. 4, and fig. 5, Appendix

1. Jack pine stand with less than minimum stocking, or area is nonstocked 10

2. Average tree d.b.h. is less than 5 inches 3
See "Size", p. 4

2. Average tree d.b.h. is 5 inches or more 4

3. 2,000 or more trees per acre . . . . . WEED OR CLEAN . . 8
See "Weeding and Cleaning", p. 6

3. Less than 2,000 trees per acre 8

4. Stand is mature 11
See "Rotation Ages", p. 7

4. Stand is not mature 5

5. **Site index 60 or better** 6
See fig. 4, "Appendix", p. 11

5. **Site index less than 60** 9

6. **Manage for large products (poles, etc.)** 7
See "Quality", p. 5

6. **Manage for small products (pulpwood, etc.)** 9

7. **120 square feet of basal area per acre or more** . . . . . THIN . . 9
See "Thinning", p. 6

7. **Less than 120 square feet of basal area per acre** 9

8. **Severe overstory competition** . . . . . RELEASE . . 9
See "Release", p. 6

8. **Overstory competition is not severe** 9

9. **High risk of injury or loss** . . . . . CONTROL IF FEASIBLE
See "Risk", p. 4

9. **Low risk of injury or loss** . . . . . WAIT

10. **Condition is needed for other resources** . . . . . MAINTAIN
See "Other Resources", p. 9

10. **Condition is not needed for other resources** 11

11. **Jack pine desired *and* site is suitable** 12
See "Site Evaluation", p. 7 and "Conversion", p. 9

11. **Jack pine not desired; *or* jack pine desired but site not suitable** . . . . . CONVERT

12. **Desirable jack pine seed source on area** 13
See "Seed Tree Requirements", p. 8

12. **No desirable jack pine seed source on area** . . . . . USE CLEARCUT . . 17

13. **Trees have serotinous cones** 14
See "Seeding", p. 9

13. **Trees have nonserotinous cones** 16

14. **10 trees per acre are adequate to seed area** 15
See "Silvicultural Systems", p. 8

14. **10 trees per acre are not adequate to seed area** . . . . . USE CLEARCUT . . 17

15. **Prescribed burning is planned** . . . . . USE SEED TREE
See "Site Preparation", p. 7

15. **Prescribed burning is not planned** . . . . . USE CLEARCUT . . 17

16. **Two commercial harvests possible and desired** . . . . . USE SHELTERWOOD . . 17
See "Silvicultural Systems", p. 8

16. **Two commercial harvests not possible *or* not desired** . . . . . USE CLEARCUT . . 17

17. **Sufficient mineral soil seedbeds free of slash and competition** 18
See "Site Preparation", p. 7

17. **Insufficient or inadequate seedbeds** . . . . . PREPARE SITE . . 18

18. **If shelterwood system is used** . . . . . USE NATURAL SEEDING
See "Silvicultural Systems", p. 8

18. **If clearcutting system is used** 19

19. **Improved planting stock available** . . . . . PLANT
See "Planting", p. 9

19. **Improved planting stock not available** 20

20. **Good supply of serotinous cones on area** . . . . . SCATTER CONES
See "Seeding", p. 9

20. **Poor supply or no serotinous cones on area** . . . . . DIRECT SEED

TIMBER MANAGEMENT CONSIDERATIONS

Stand Conditions

Jack pine stands and potential jack pine sites need to be carefully examined on the ground to best determine their condition, but use of aerial photos, maps, and other sources of information should not be overlooked. The stand – or site – condition, which is the basis for recommendations, includes type, age, size, density, risk, quality, productivity, and operability.

Type

Jack pine grows in extensive pure stands as well as various mixtures in which it is the predominant species. Common associated species in mixed stands are red and white pine, quaking and bigtooth aspen, paper birch, northern red oak, and northern pin oak. Other associates include black spruce, white spruce, balsam fir, and bur oak. In addition to the species composition of the main stand, important understory tree or shrub species should be noted so they can be evaluated for site preparation needs and for other single or multiple uses. Dry, sandy areas that are nonstocked or poorly stocked may be suitable sites to establish jack pine seedlings.

Age

The total age of dominant and codominant trees will aid in estimating site productivity and comparing the present stand with its potential condition. Total age in jack pine can be estimated by adding 6 years to age at breast height (4.5 feet above ground) or 2 years to age of plantations. Rotation ages for jack pine are discussed on page 7.

Size

Jack pine stands are classified as seedling stands (up to 2 inches average d.b.h.), sapling (2 to 5 inches), pole (5 to 9 inches), and sawtimber (9 inches and over). Estimated tree diameters and basal areas at age 20 are strongly influenced by stand density and site (tables 1 and 2, p. 12, Appendix). In stands with more uniform stand density, tree size will also be more uniform.

Stand Density

Two important aspects of stand density in jack pine stands are the stocking level and uniformity. As the stocking level decreases toward the minimum stocking, uniformity or distribution of the trees in the stand increases in importance. The minimum stocking in basal area and number of trees for uniform stands of various average stand diameters was calculated from the maximum amount of growing space trees of each diameter could use (fig. 5, p. 11, Appendix). Minimum stocking for stands averaging 4 inches in diameter is about 600 trees and 50 square feet of basal area per acre. In stands averaging 12 inches in diameter minimum stocking is about 100 trees and 80 square feet of basal area per acre. The recommended upper limit of stocking for managed stands is based on 85 percent of a normal yield table for pole stands (5 to 9 inches average diameter) and 100 percent for sawtimber stands (fig. 5, p. 11, Appendix). The recommended upper limit of stocking for managed stands averaging 5 inches in diameter is about 800 trees and 110 square feet of basal area per acre. For stands averaging 9 inches in diameter it is about 300 trees and 140 square feet of basal area per acre.

In seedling stands less than 5 years old stocking can be estimated by percent of milacre plots with at least one seedling (a "stocked" milacre). A minimum of 60 percent stocked milacres would provide good seedling distribution and indicate at least 600 trees per acre, which is the recommended minimum stocking for stands averaging 4 inches d.b.h. In older seedling stands (over 5 years old) 1/100-acre sample plots are recommended to estimate number of trees per acre and average tree size. Although understocked stands are generally more of a problem than overstocked stands, dense sapling stands (2 to 5 inches average d.b.h.) with more than 2,000 trees per acre develop weak spindly trees that may tend to stagnate.

Risk of Loss from Damaging Agents

High risk jack pine trees are those damaged by diseases, insects, animals, fire, or weather. Risk depends on the degree of injury and the chances for the tree to recover. Trees in young, vigorous, fully stocked stands have the best chances.

Weather damage includes flooding, drought, lightning strikes, and breakage by ice, hail, snow, and wind storms. Storms may also leave thin-crowned weakened trees susceptible to further injury from other environmental stresses.

Fire damages jack pine of all sizes. Surface fires will kill seedlings and saplings and hot fires sometimes

completely kill pole stands. Trees that survive fires are often scarred and weakened making them poor risks. Prescribed burning is not recommended in immature jack pine stands. Firebreaks should be used to help reduce the spread of wildfires.

Jack pine seedlings may be severely browsed by deer which sometimes kill trees up to 10 years old. Browsing retards height growth and often deforms young trees. Dense seedling and sapling stands provide good cover for snowshoe hares that may girdle many trees during high populations. Porcupines sometimes seriously damage older trees by stripping the soft bark near the tops of large trees.

Many insects attack jack pine. One of the most serious pests is the jack pine budworm. The budworm defoliates trees of all sizes but the older, less vigorous trees growing under stress, such as on poor sites and during droughts, suffer greater losses. Losses are related to the intensity of defoliation and the vigor of the trees and include tree mortality, reduced volume and lower quality caused by top kill, reduced growth, and reduced seed production. Trees weakened by budworm defoliation are more susceptible to other insect pests such as the ips bark beetle. Bark beetle outbreaks on healthy trees occur when the insect population builds up in fresh slash or on weakened trees and can successfully attack neighboring trees, especially during drought conditions. Vigorous stands have less risk of injury from insect attacks. Best control measures are to harvest budworm-infested stands at 40 years of age or as soon as merchantable to discourage further buildup. Risk of bark beetle attacks on healthy trees can be reduced by removing fresh slash from around residual trees, such as by full-tree skidding.

Other insects that are found on jack pine include the pine root collar weevil, several pine sawflies, pitch nodule maker, pine chafer beetle, white pine weevil, pine tussock moth, pine tortoise scale, eastern pine shoot moth, pine tip moth, Zimmerman pine moth, pine webworm, and a root tip weevil. Although these insects may cause severe losses on occasion, the risk can be minimized by maintaining vigorous stands.

Diseases of jack pine include several stem rusts such as eastern gall rust, stalactiform rust, sweet fern rust, comandra rust, and western gall rust. Other important diseases include Armillarea root rot, Scleroderris canker, and *Fomes pini.* Trees weakened by drought, or by other injuries, have the greatest risk of succumbing to attacks.

Quality

Jack pine tree quality is related to size, form, straightness, branching habit, and damage caused by injuries. Low density stands tend to have poorer quality trees because of more taper, crookedness, and larger branches; but overdense stands with more than 2,000 trees per acre can produce weak spindly trees that are also poor quality. Most jack pine stands will probably be managed for small roundwood products such as pulpwood but some stands – especially on the better sites – can be managed for poles and small sawtimber if the trees are reasonably straight, have little taper, small branches, and little or no injury that will hinder their growth and development. The wide range of genetic variation in jack pine makes it possible to improve future stands by selecting the best quality trees for seeding new stands.

Productivity

Site index is the height attainable by the average dominant and codominant trees in relatively pure, even-aged, and well stocked stands at the age of 50 years (see page 11 and fig. 4, Appendix). The productivity of a *stand* can be estimated from its site index with the aid of the growth and yield tables in the Appendix (tables 3-7). Volumes in cubic feet and cords are shown for site indices 40, 50, 60, and 70 at several different ages and for stand densities of 30, 60, 90, 120, and 150 square feet of basal area per acre (tables 4 and 6, Appendix). Current annual growth is also shown for these same stand conditions (tables 5 and 7, Appendix) so that growth of any stand can be projected for the next growth period. If projections are made for more than 10 years, it would be best to interpolate a new current annual growth from the table or use the equations given in the table to compute the periodic annual growth for the period desired.

Operability

Markets, access, and volume of products that are removed determine operability. The value of the product is also important so higher value products will usually make the stand operable with lower volumes. It is suggested that jack pine stands have a minimum volume of 100 cords at maturity or a minimum area of 10 acres but about 40 acres are recommended for establishing new stands.

Controlling Composition and Growth

Release

Jack pine is so intolerant that it cannot survive long with overhead shade. On very dry sites, however, especially during droughts, some shade from trees, shrubs, or slash may be beneficial by lowering surface temperatures and reducing evapotranspiration. As soon as seedlings are established they should be given full sunlight on all sites. Jack pine seedlings grow rapidly in height after the first couple of years and can usually keep ahead of the competition except on the better sites. Where competition is more than just a few trees or shrubs the most practical control method is with herbicide foliage sprays. The use of chemical herbicides requires strict adherance to label instructions. Two of the most useful herbicides are 2,4-D and 2,4,5-T.[3] Jack pine may be injured by these herbicides if spraying is done too early. Spraying should be done in the first 2 weeks of August for good control of hardwoods and because the risk of injuring jack pine is low. Most of the common competing species can be controlled with 2,4-D but blackberries, raspberries, roses, juneberries, prickly ash, oaks, and maples are resistant to it. All of these species except the maples can be controlled with 2,4,5-T. Maples are difficult to control with foliar sprays but felling the tree and spraying the stump with chemicals containing 2,4,5-T is effective.

Weeding and Cleaning

Overstocking of jack pine seedlings and saplings occurs less frequently than understocking but dense stands with 2,000 or more trees per acre should be weeded or cleaned for improved growth and development. Weeding is done during the seedling stage of stand development and cleaning during the sapling stage to provide more growing space for the potential crop trees. Seedling and sapling stands do not usually have merchantable material so weeding and cleaning are often referred to as "precommercial thinning". In very dense stands (i.e., 10,000 trees per acre) mechanical methods that clear strips about 8 feet wide and leave strips of trees about 2 feet wide are more efficient than operations that leave 800 to 1,000 uniformly spaced crop trees.

Thinning

Jack pine stands on the better sites (site index 60 and over) can be thinned to about 80 square feet of basal area per acre to increase the production of poles and small saw logs. Thinnings should not remove over one-third of the basal area to minimize post-logging mortality. Dense stands may require a couple of thinnings to safely reduce the basal area to 80 square feet per acre. Removing every third, fourth, or fifth row is recommended only when economics or high stand densities prevent marking individual trees. Thinnings should generally be from below – removing the smaller, slower growing trees to favor the larger crop trees, but high risk, poor quality, or damaged trees of any size should be removed to improve the stand. In mixed stands, the more valuable or desirable species should be favored. On these better sites jack pine is a temporary type that will most likely be replaced by a more suitable species at the end of the rotation.

On the less productive sites or in stands managed for small roundwood products such as pulpwood, thinnings are not recommended (fig. 1).

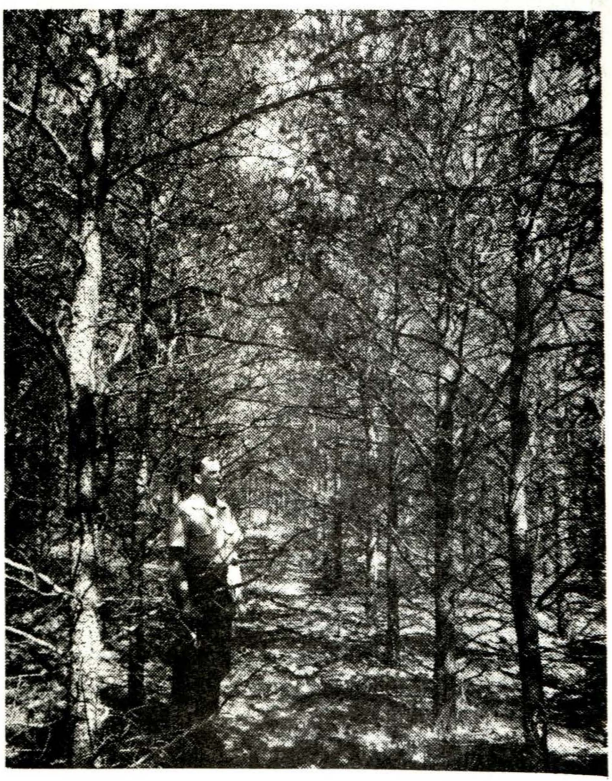

Figure 1. – *Jack pine planted at 7 x 7 foot spacing produces a uniform stand at age 20 and will not require thinning for a pulpwood rotation of 40 to 50 years.*

[3] *See Pesticide Precautionary Statement, p. 16.*

Rotation Ages

Jack pine is a relatively short-lived species reaching maturity between 40 and 70 years (fig. 2). Mean annual growth in cords culminates earlier in high density stands than in low density stands (table 8, Appendix). Low density stands at older ages – 30 square feet of basal area per acre or less at age 40 and 60 square feet at age 50 – should be harvested and regenerated because they will not reach full stocking by age 70. Poor sites will not reach high basal area densities at young ages but some stands may be overstocked with numbers of trees per acre, thus requiring weeding or cleaning to avoid stagnation.

Figure 2. – *This jack pine stand is about 50 years old and has reached the recommended rotation age for pulpwood, however another 20 years is recommended to produce poles and sawtimber.*

On the better sites poles and small sawtimber may be grown with 70-year rotations, especially in stands that are thinned to basal area densities of 80 square feet per acre at 30 to 40 years of age so the trees maintain good diameter growth. Cordwood production is best in the denser stands and may culminate as early as 40 years.

Other factors may require shorter rotations in some stands to reduce the risk of serious losses. Budworm injury, disease attacks, fire scars, or severe weather stresses may indicate rotation ages of 40 years or less. Stands on poor sites are often under more stress than those on the better sites and they usually do not reach merchantable size as early because of slower growth. High risk stands should be harvested at rotation ages of 40 years or as soon as merchantable.

Rotation ages in stands managed primarily for resources other than timber depend on the health and vigor of the stand and the environmental conditions required for the resource. They will not generally be over 70 years as most stands become decadent about that age but they may be any younger age that provides the needed conditions.

Controlling Stand Establishment

Site Evaluation

Jack pine does best on well drained loamy sands but is more common on the dry sandy soils where it is better adapted than most other species. It is also found on eskers, sand dunes, and rocky soils. Jack pine is an intolerant pioneer species that typically colonizes burns and bare mineral soil areas. Successional changes are relatively fast on all but the deep dry sandy soils such as Grayling, Rubicon, Plainfield, Vilas, and Menagha where changes are often so slow that jack pine is sometimes considered the edaphic climax.

In evaluating sites for establishing jack pine stands both the productivity and the site preparation needs should be considered. Productivity of jack pine stands can be estimated from site index curves (fig. 4, Appendix, p. 11) in combination with stand volume tables (table 4 or 6, Appendix, p. 13 & 14). Site preparation needs may also be related to site quality. Generally the higher the site quality the greater the need to control competing sod, shrubs, and trees to favor the establishment of jack pine. On the sites with strong tendencies toward successional change conversion to a more valuable or desirable species such as red pine may be considered.

Site Preparation

Three major objectives of site preparation are (1) treating the slash to reduce the fire hazard and the hindrance to regeneration, (2) controlling shrubs and other competition, and (3) exposing mineral soil seedbeds. One, two, or all three of these objectives may be required, depending on the site conditions (fig. 3).

Figure 3. – *Some kind of site preparation is usually needed after harvesting mature jack pine to dispose of slash, remove unwanted trees and shrubs, and expose mineral soil seedbeds.*

Slash treatments include removing it from the area such as by pushing it aside with a bulldozer and by full-tree skidding, or modifying the slash on the area. Modifying the slash on the area includes prescribed burning, chipping, discing, chopping, and breaking it up with various types of drags. The method of slash treatment should be selected according to the results desired and to fit as many of the other site preparation needs of the area as possible.

Controlling shrubs and other competition may be accomplished while treating the slash or may require another operation. Light shrub cover can be controlled by full-tree skidding, hand-cutting, hand-scalping, or machine scalping such as with furrowing plows and specially designed scalping cultivators. Medium shrub cover may require discing or roller-chopping, and heavy shrub cover often requires bulldozing, shearing, rock raking, root raking, prescribed burning, or the use of herbicides. Combinations of these methods may be needed in some cases to obtain the desired results. Sod competition presents a special problem and should be controlled in conjunction with preparing seedbeds.

The best jack pine seedbeds are bare mineral soil. Seedbeds of mixed humus and mineral soil are generally not as good because roots and seeds in the humus result in increased competition. Prescribed burning leaves a seedbed that is more variable. If the fire is hot enough to consume most of the humus, the seedbed is almost as good as bare mineral soil, but if an inch or so of the humus remains, the seedbed is more like those prepared by mixing the humus and mineral soil. Light fires or spring fires that leave most of the humus unburned do not prepare good seedbeds. Undisturbed humus is also considered a poor seedbed under most conditions. Differences among the various seedbeds may be small when weather conditions for germination and survival are good, but when they are not, seedbeds can determine success or failure. Many kinds of mechanical equipment can be used to prepare scalped or mixed humus seedbeds including most of those described for controlling shrubs. Prescribed burning should be limited to areas that have sufficient fuels (including slash) for hot enough fires to prepare good seedbeds.

Silvicultural Systems

Jack pine seedlings require full sunlight to be successfully established. Clearcutting, seed tree, or shelterwood silvicultural systems may be appropriate depending on the stand and site conditions.

Clearcutting is the recommended silvicultural system for harvesting mature trees where a new stand will be established by planting improved seedlings, direct seeding, or scattering serotinous cones from high quality trees. Clearcutting may also be appropriate for mature stands that have an understory of fully stocked seedlings. Some jack pine stands were established by seeding from the cull trees left on pine-harvested areas and some of the planting stock used in plantations was grown from seed of other geographic areas and sometimes even from poor quality open grown trees. If the mature stand is not a suitable seed source for regenerating a new seedling stand, prescribed burning followed by planting or direct seeding with a desirable seed source should be considered. If the tree quality is desirable and the cones are serotinous, a new seedling stand can be established by scattering cone-bearing branches on bare mineral soil seedbeds. The heat near the ground surface will open the cones and release the seed. The branches will provide light beneficial shade during germination but care is needed to avoid accumulations of slash that might interfere with later seedling development or present a fire hazard during the most vulnerable seedling stage of development.

The seed tree system is recommended as a possible alternative for stands that have 10 well-distributed, desirable quality seed trees per acre with an abundant supply of serotinous cones. Prescribed burning is recommended to consume the slash, kill the competition,

prepare favorable seedbeds, and open the serotinous cones on the seed trees to seed the area. Careful selection of high quality seed trees can improve the quality of the seedling stand. It is important to burn the slash soon after harvesting to minimize the risk of losing seed trees by windthrow before the cones are opened by the fire and the seeds dispersed. Jack pine slash requires about a month of warm, dry weather to cure adequately for effective burning. Early spring fires will result in seeding at the most favorable season but late fall fires may be almost as effective if the seed overwinters safely for early spring germination. If weather conditions following seed dispersal are unfavorable for seedling establishment, direct seeding or planting may be required as the seed trees will have been killed by the fire.

The shelterwood system is recommended only for vigorous, well stocked stands with 30 to 40 square feet of basal area per acre in desirable quality trees with nonserotinous cones that can be left after the regeneration cut to seed the area. Site preparation as discussed under "Site Evaluation" is an important requirement to assure seedling establishment. The removal cut should be made as soon as the seedling stand has 60 percent milacre stocking or within 10 years. Prompt removal of the shelterwood overstory will minimize volume losses due to mortality following the regeneration cut, seedling losses due to logging damage and suppression, and will reduce the risk of budworm buildup in the overstory and subsequent defoliation of seedlings.

Conversion

Jack pine is a pioneer, temporary type on nearly all sites except the dry sandy soils. Successional forces generally increase as site quality increases adding to the difficulty of maintaining jack pine on better sites. Many of the other species that are better adapted to these sites are also more productive and more valuable. On such areas jack pine should be converted to another forest type at the end of the rotation.

In mixed stands the conversion may be accomplished gradually by harvesting the jack pine in several cuts if the more desirable species have sufficient stocking. If there is insufficient stocking of the other species or the stand is essentially pure, jack pine should be converted by clearcutting and planting either red pine or white spruce, depending on the site.

Seeding and Planting

In areas where favorable soil moisture conditions can be expected as a result of a water table within a few feet of the surface, or frequent precipitation during the period of germination and early seedling development, it will be possible to establish a seedling stand by direct seeding repellent-treated seed. Seed should be coated with bird and rodent repellents (such as Arasan) and sown at the rate of 20,000 viable seeds per acre (about 3 ounces) early in the spring to take advantage of snowmelt waters for germination. Although jack pine is one of the most successful species for direct seeding, failures can be expected if precipitation is lacking for more than a few days during seed germination or more than a week during early seedling establishment, especially on the droughty soils. Usually the seedbeds on these sites will be suitable for reseeding the second or third year if unusually poor weather conditions cause the first seeding to fail.

Some areas that have been unsuccessfully seeded will require planting as will many areas with deep, dry sandy soils. Bare root stock should be planted only in the spring but container-grown stock can be planted in the summer as well. About a 6- to 8-foot spacing is usually recommended for jack pine.

OTHER RESOURCE CONSIDERATIONS

Recreation

Jack pine stands can be an important part of the visual resource for recreation. Harvesting, site preparation, and regeneration practices make major changes in the appearance of an area and require careful planning and execution to ultimately achieve the esthetic appeal that is desired. The size and shape of harvested areas can be very effective in improving the overall appearance of some areas if they are tailored to the general surroundings. Good workmanship and cleanup are musts to improve the recreational values on any area. On developed recreation areas we recommend that jack pine be gradually converted to a species that is less sensitive to disturbance and longer lived.

Opportunities for blueberry picking, an activity enjoyed by many people, may be increased on some jack

pine areas during the regeneration period, especially if site preparation methods – such as prescribed burning or scarification – prune the tops of blueberry bushes without damaging their roots so that vigorous new shoots develop to produce large crops of blueberries.

Water

Management of jack pine stands that cover only a part of a watershed should be coordinated with management of other areas in that watershed to maintain even annual flows of high quality water. Forests that cover whole watersheds will minimize seasonal fluctuations and stabilize annual flows when they are fully regulated. Care is needed in harvesting trees near streams and lakes to prevent soil and debris from getting into the water. Some stream crossings may require culverts. Careful planning of landings and trails should keep stream crossings to a minimum. Heavy equipment should be kept away from shorelines and stream banks to prevent soil from eroding into the water. Trees should be felled away from the water and winched when necessary to the nearest skid trail. Intermittent stream channels should not be used for skidding. Timber harvesting when soils are frozen will reduce erosion hazards on some areas.

Wildlife

Jack pine is generally considered a medium preference deer food, the same as aspen. Young trees may be heavily browsed where deer populations are high. Dense sapling and pole stands offer some wind protection and winter shelter but generally jack pine stands do not provide as good winter shelter as most other conifers. Because older stands of jack pine are usually less dense than other conifers, the understory shrubs and herbaceous plants have better growth and thus provide a better food supply.

Some wildlife species benefit from special stand conditions such as the excellent cover that dense young stands of jack pine provide for hares. Clumpy stands of young trees with branches reaching the ground provide nesting sites for the endangered Kirtland's Warbler in the Lower Peninsula of Michigan. Most wildlife species that find food or shelter in jack pine forests will benefit from management efforts to provide a good distribution of age classes.

APPENDIX
Site Index, Stocking

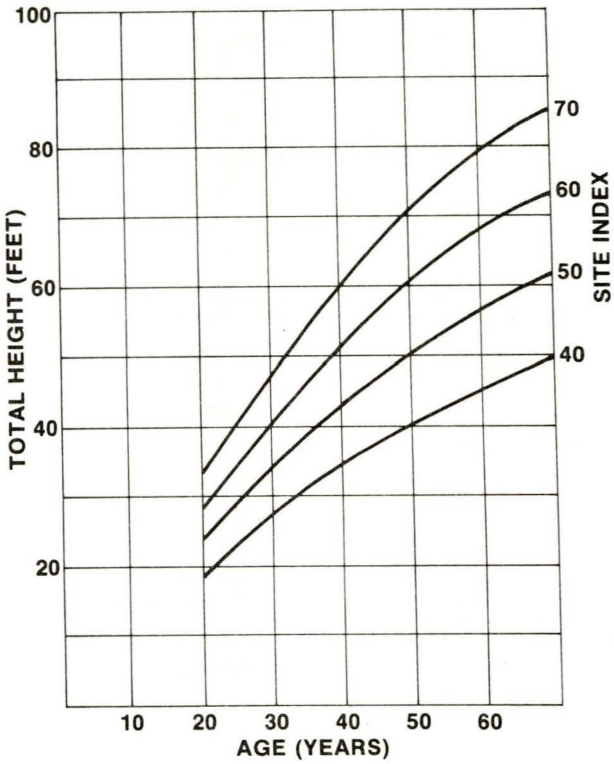

Figure 4. – *Jack pine site index curves. Based on the equation by Lundgren and Dolid (1970): height = 1.633 (site index) (1 - e $^{-0.02233 (age)}$) $^{1.2419}$.*

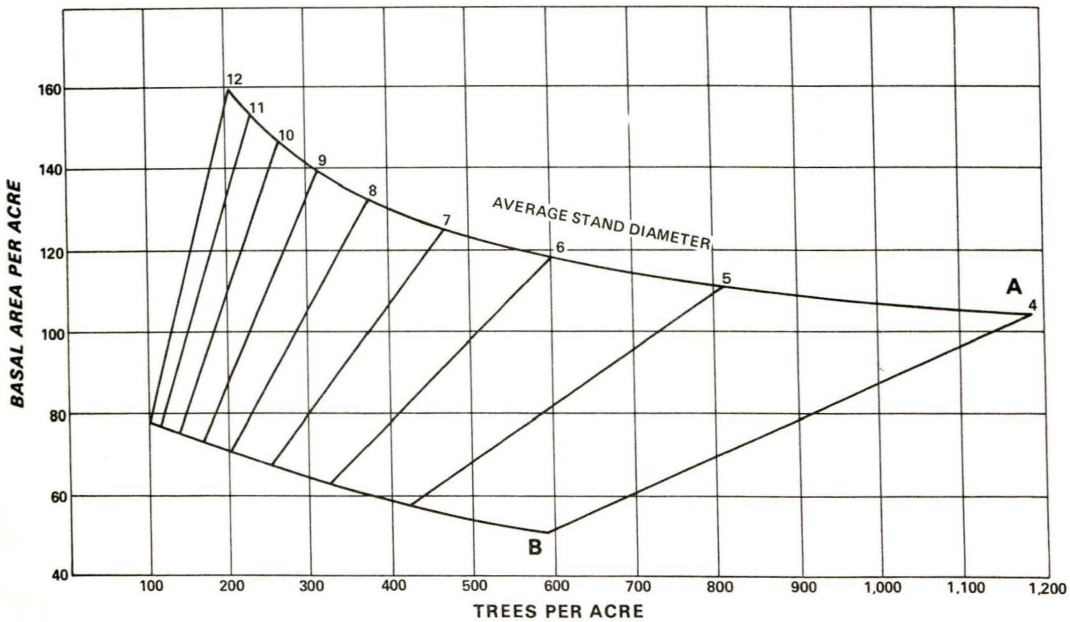

Figure 5. – *Stocking chart for jack pine stands. Recommended upper limit (A curve) is based on stand tables from Eyre and LeBarron (1944) and adjusted to approximately 85 percent stocking for poletimber and 100 percent stocking for sawtimber stands. Minimum stocking (B curve) is based on crown width for open-grown trees from Bella (1967).*

Table 1. – *Estimated average d.b.h. in 20-year-old jack pine stands*

Site index	Number of trees per acre			
	500	1000	1500	2000
Feet	*Inches*			
70	4.4	4.0	3.7	3.3
60	3.8	3.4	3.1	2.9
50	3.2	2.9	2.6	2.4
40	2.5	2.3	2.1	1.9

Source: Laidly, Paul. 1976. Unpublished analysis of jack pine growth studies at the Northern Conifers Laboratory, Grand Rapids, Minnesota.

Table 2. – *Estimated basal area per acre in 20-year-old jack pine stands*

Site index	Number of trees per acre			
	500	1000	1500	2000
Feet	*Square feet*			
70	53	87	112	119
60	39	63	79	92
50	28	46	55	63
40	17	29	36	39

Source: Laidly, Paul. 1976. Unpublished analysis of jack pine growth studies at the Northern Conifers Laboratory, Grand Rapids, Minnesota.

Table 3. – *Current annual basal area growth per acre*[1] *for jack pine stands by site, age, and stand density*

Total age	Total height	Stand density basal area per acre				
		30	60	90	120	150
Years	*Feet*	*Square feet*				
SITE INDEX 70						
20	32	3.8	4.9	5.0	4.1	--
30	47	2.1	2.8	2.8	2.3	1.2
40	59	1.4	1.8	1.9	1.5	.8
50	70	1.0	1.3	1.4	1.1	.6
60	78	.8	1.1	1.1	.9	.5
70	85	.7	.9	.9	.7	.4
SITE INDEX 60						
20	28	3.4	4.5	4.6	--	--
30	40	1.9	2.5	2.6	2.1	--
40	51	1.3	1.6	1.7	1.4	.7
50	60	.9	1.2	1.2	1.0	.5
60	67	.7	1.0	1.0	.8	.4
70	73	.6	.8	.8	.7	.4
SITE INDEX 50						
20	23	3.1	4.0	--	--	--
30	34	1.7	2.2	2.3	--	--
40	42	1.1	1.5	1.5	1.2	--
50	50	.8	1.1	1.1	.9	.5
60	56	.7	.9	.9	.7	.4
70	61	.6	.7	.7	.6	.3
SITE INDEX 40						
20	18	2.7	--	--	--	--
30	27	1.5	1.9	1.3	--	--
40	34	1.0	1.3	1.3	--	--
50	40	.7	.9	1.0	.8	--
60	45	.6	.8	.8	.6	.3
70	49	.5	.6	.6	.5	.3

[1]Based on the equation: current annual basal area growth per acre = $0.276\ (\text{site index})^{-0.63}\ \text{Exp}\ (-4\ \text{Exp}\ (-29.18/\text{Age}))\ (1 + 0.56\ (\text{basal area}) - 0.00358\ (\text{basal area})^2)$.

Source: Laidly, Paul. 1976. Unpublished analysis of jack pine growth studies at Northern Conifers Laboratory, Grand Rapids, Minnesota.

Table 4. – *Volume in cubic feet*[1] *per acre for jack pine stands by site, age, and stand density*

Total Age	Total height	Stand density – basal area per acre: 30	60	90	120	150
Years	*Feet*	*Cunits (100 cubic feet) per acre*				
SITE INDEX 70						
20	32	3.9	7.8	11.8	15.7	--
30	47	5.7	11.5	17.3	23.0	28.8
40	59	7.2	14.5	21.7	28.9	36.2
50	70	8.6	17.2	25.7	34.3	42.9
60	78	9.6	19.1	28.7	38.2	47.8
70	85	10.4	20.8	31.2	41.7	52.1
SITE INDEX 60						
20	28	3.4	6.9	10.3	--	--
30	40	4.9	9.8	14.7	19.6	--
40	51	6.2	12.5	18.8	25.0	31.2
50	60	7.4	14.7	22.1	29.4	36.8
60	67	8.2	16.4	24.6	32.8	41.1
70	73	8.9	17.9	26.8	35.8	44.7
SITE INDEX 50						
20	23	2.8	5.6	--	--	--
30	34	4.2	8.3	12.5	--	--
40	42	5.1	10.3	15.4	20.6	--
50	50	6.1	12.3	18.4	24.5	30.6
60	56	6.9	13.7	20.6	27.4	34.3
70	61	7.5	15.0	22.4	29.9	37.4
SITE INDEX 40						
20	18	2.2	--	--	--	--
30	27	3.3	6.6	--	--	--
40	34	4.2	8.3	12.5	--	--
50	40	4.9	9.8	14.7	19.6	--
60	45	5.5	11.0	16.5	22.1	27.6
70	49	6.0	12.0	18.0	24.0	30.0

[1]Gross cubic-foot peeled volume entire stems of all trees based on equation:
Volume = .4085 (basal area x height).
Source: Buckman, Robert E. 1961.

Table 5. – *Current annual cubic foot growth*[1] *per acre for jack pine stands by site, age, and stand density*

Total age	Total height	Stand density – basal area per acre: 30	60	90	120	150
Years	*Feet*	*Cubic feet*				
SITE INDEX 70						
20	32	72	106	127	135	--
30	47	59	90	107	114	110
40	59	48	71	87	91	87
50	70	40	60	74	76	73
60	78	36	55	65	68	65
70	85	32	46	54	54	51
SITE INDEX 60						
20	28	57	86	103	--	--
30	40	47	71	88	94	--
40	51	40	58	73	79	76
50	60	32	49	59	64	61
60	67	28	45	53	56	54
70	73	24	36	42	46	43
SITE INDEX 50						
20	23	44	66	--	--	--
30	34	37	56	70	--	--
40	42	29	46	56	60	--
50	50	25	40	49	53	53
60	56	22	33	39	41	40
70	61	20	27	32	35	32
SITE INDEX 40						
20	18	32	--	--	--	--
30	27	27	41	--	--	--
40	34	21	33	40	--	--
50	40	18	27	35	38	--
60	45	16	25	30	31	30
70	49	15	22	27	30	30

[1]Based on the following equation: gross cubic-foot peeled volume growth entire stems of all trees = .4085 (basal area growth x height + height growth x basal area + basal area growth x height growth).

Table 6. – *Volume in cords per acre*[1] *for jack pine stands by site, age, and stand density*

Total age	Total height	Stand density – basal area per acre: 30	60	90	120	150
Years	*Feet*	*Cords*				
SITE INDEX 70						
30	47	5.6	11.2	16.7	22.3	--
40	59	7.0	14.0	21.0	28.0	35.0
50	70	8.3	16.6	24.9	33.2	41.6
60	78	9.3	18.5	27.8	37.0	46.3
70	85	10.1	20.2	30.3	40.4	50.5
SITE INDEX 60						
30	40	4.7	9.5	14.2	--	--
40	51	6.1	12.1	18.2	24.2	--
50	60	7.1	14.2	21.4	28.5	35.6
60	67	8.0	15.9	24.0	31.8	39.8
70	73	8.7	17.3	26.0	34.7	43.3
SITE INDEX 50						
40	42	5.0	10.0	15.0	--	--
50	50	5.9	11.9	17.8	23.7	--
60	56	6.6	13.3	19.9	26.6	33.2
70	61	7.2	14.5	21.7	29.0	36.2
SITE INDEX 40						
40	34	4.0	8.1	--	--	--
50	40	4.7	9.5	14.2	--	--
60	45	5.3	10.7	16.0	21.4	--
70	49	5.8	11.6	17.5	23.3	29.1

[1]Based on the equation: Volume = .003958 (basal area x height). Includes gross cordwood volume in rough cords of all stems per acre 3.6 inches d.b.h. and larger to a variable top d.i.b. of not less than 3 inches.

Source: Buckman, Robert E. 1961.

Table 7. – *Current annual cordwood growth*[1] *per acre for jack pine stands by site, age, and stand density*

Total age	Total height	Stand density – basal area per acre: 30	60	90	120	150
Years	*Feet*	*Cords*				
SITE INDEX 70						
30	47	0.6	0.9	1.0	1.1	--
40	59	.5	.7	.8	.9	.8
50	70	.4	.6	.7	.7	.7
60	78	.3	.5	.6	.7	.6
70	85	.3	.4	.5	.5	.5
SITE INDEX 60						
30	40	.5	.7	.8	--	--
40	51	.4	.6	.7	.8	--
50	60	.3	.5	.6	.6	.6
60	67	.3	.4	.5	.5	.5
70	73	.2	.4	.4	.4	.4
SITE INDEX 50						
40	42	.3	.4	.5	--	--
50	50	.2	.4	.5	.5	--
60	56	.2	.3	.4	.4	.4
70	61	.2	.3	.3	.3	.3
SITE INDEX 40						
40	34	.2	.3	--	--	--
50	40	.2	.3	.3	--	--
60	45	.2	.2	.3	.3	--
70	49	.1	.2	.3	.3	.3

[1]Based on the equation: Cordwood growth = .003958 (basal area growth x height + height growth x basal area + basal area growth x height growth). Includes gross cordwood growth in rough cords of all stems per acre 3.6 inches d.b.h. and larger to a variable top d.i.b. of not less than 3 inches.

Table 8. – *Recommended rotation ages for jack pine stands without future thinnings by present stand age and density; and mean annual growth in cords for the recommended rotations by site index*

Present age	Present stand density – basal area per acre (square feet): 30	60	90	120
Years	*Years*			
	ROTATION AGE			
20	70	60	50	40
30	70	70	50	40
40	--	70	60	50
50	--	--	70	60
	MEAN ANNUAL GROWTH			
	SITE INDEX 70			
	Cords			
20	0.6	0.7	0.8	0.9
30	.4	.6	.7	.8
40	--	.5	.6	.7
50	--	--	.5	.7
	SITE INDEX 60			
20	.5	.6	.7	--
30	.3	.5	.6	.7
40	--	.4	.5	.6
50	--	--	.4	.6
	SITE INDEX 50			
20	.4	.5	--	--
30	.3	.4	.5	--
40	--	.3	.4	.5
50	--	--	.4	.5
	SITE INDEX 40			
20	.3	--	--	--
30	.2	.3	--	--
40	--	.2	.3	--
50	--	--	.3	.4

[1]Calculated from basal area growth equation (table 3) and cordwood volume equation (table 6). Rough cords for trees 3.6 inches d.b.h. and larger to a 3-inch top d.i.b.

Metric Conversion Factors

To convert	*to*	*Multiply by*
Acres	Hectares	0.405
Board feet[1]	Cubic meters	0.005
Board feet/acre[1]	Cubic meters/hectare	0.012
Chains	Meters	20.117
Cords[1]	Cubic meters	2.605
Cords/acre[1]	Cubic meters/hectare	6.437
Cubic feet	Cubic meters	0.028
Cubic feet/acre	Cubic meters/hectare	0.070
Degrees Fahrenheit	Degrees Celsius	[2]
Feet	Meters	0.305
Gallons	Liters	3.785
Gallons/acre	Liters/hectare	9.353
Inches	Centimeters	2.540
Miles	Kilometers	1.609
Miles/hour	Meters/second	0.447
Number/acre	Number/hectare	2.471
Ounces	Grams	28.350
Ounces/acre	Grams/hectare	70.053
Pounds	Kilograms	0.454
Pounds/acre	Kilograms/hectare	1.121
Pounds/gallon	Kilograms/liter	0.120
Square feet	Square meters	0.093
Square feet/acre	Square meters/hectare	0.230
Tons	Metric tons	0.907
Tons/acre	Metric tons/hectare	2.242

[1]The conversion of board feet and cords to cubic meters can only be approximate; the factors are based on an assumed 5.663 board feet (log scale) per cubic foot and a cord with 92 cubic feet of solid material.

[2]To convert °F to °C, use the formula 5/9 (°F-32) or $\frac{°F-32}{1.8}$.

Common and Scientific Names of Plants and Animals

Common name	*Scientific name*
Plants	
Aspen, bigtooth	*Populus grandidentata*
quaking	*Populus tremuloides*
Birch, paper	*Betula papyrifera*
Blackberries	*Rubus occidentalis*
Blueberries	*Vaccinium spp.*
Comandra rust	*Cronartium comandrae*
Eastern gall rust	*Cronartium quercuum*
Fir, balsam	*Abies balsamea*
Hazel	*Corylus spp.*
Juneberries	*Amelanchier spp.*
Maple, red	*Acer rubrum*
sugar	*Acer saccharum*
Oak, bur (scrub)	*Quercus macrocarpa*
no. pin	*Quercus ellipsoidalis*
no. red	*Quercus rubra*
Pine, jack	*Pinus banksiana*
red	*Pinus resinosa*
white	*Pinus strobus*
Prickley ash	*Xanthoxylum americanum*
Raspberries	*Rubus strigosus*
Root rot	*Armillarea mellia*
Roses	*Rosa spp.*
Spruce, black	*Picea mariana*
white	*Picea glauca*
Stalactiform rust	*Cronartium coleosporioides*
Sweetfern	*Comptonia peregrina*
Sweetfern rust	*Cronartium comptoniae*
Tar spot needle cast	*Davisomycella ampla*
Western gall rust	*Peridermium harknessii*
Animals	
Bark beetle	*Ips pini*
Deer	*Odocoileus virginianus*
Eastern pine shoot moth	*Eucosma sonomana*
Hare	*Lepus americanus*
Jackpine budworm	*Choristoneura pinus*
Kirtland's Warbler	*Dendroica kirtlandii*
Mice	*Microtus pennsylvanicus*
Pine chafer beetle	*Anomala oblivia*
Pine root collar weevil	*Hylobius radicis*
Pine tip moth	*Rhyacionia adana*
Pine tortoise scale	*Toumeyella numismaticum*
Pine tussock moth	*Dasychira plagiata*
Pine webworm	*Tetralopha robustella*
Pitch nodule maker	*Petrova albicapitana*
Porcupine	*Erethizon dorsatum*
Root tip weevil	*Hylobius spp.*
Sawflies	*Neodiprion spp.*
White pine weevil	*Pissodes strob.*
Zimmerman pine moth	*Dioryctria zimmermani*

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key – out of the reach of children and animals – and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

Note: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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